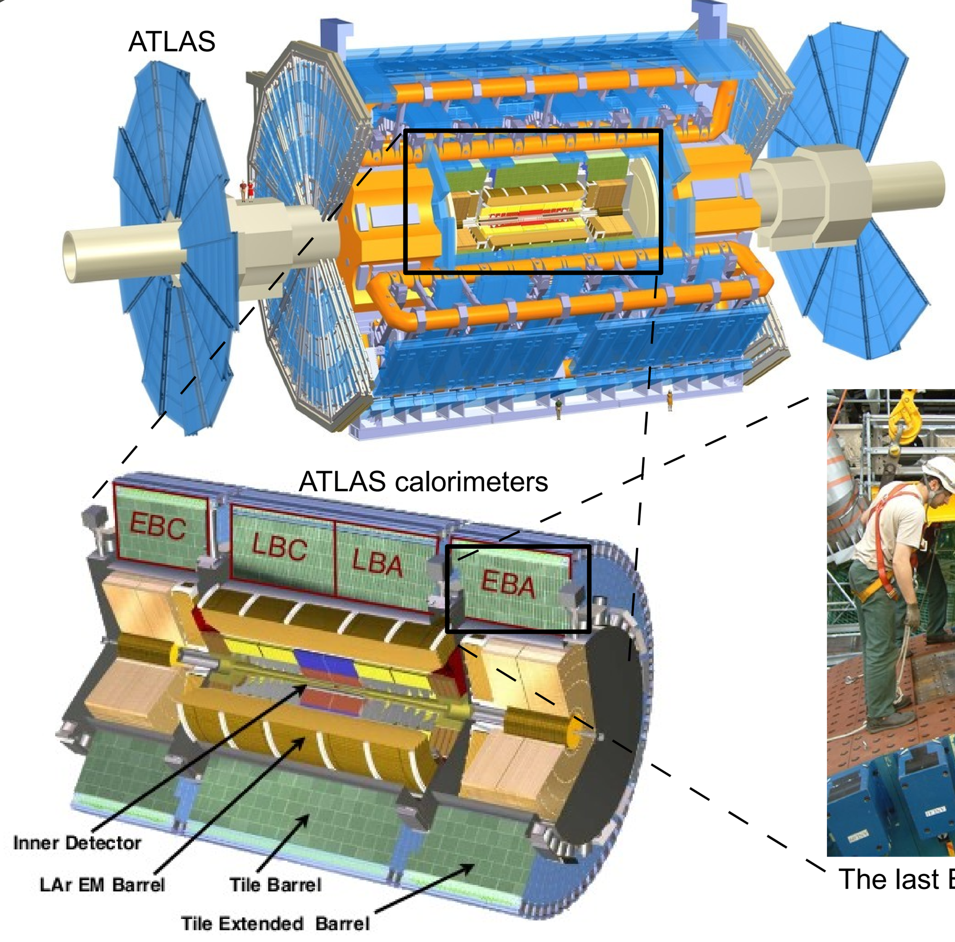
Commissioning of the ATLAS Tile Calorimeter

J. Maneira (LIP-Lisboa), on behalf of the TileCal community

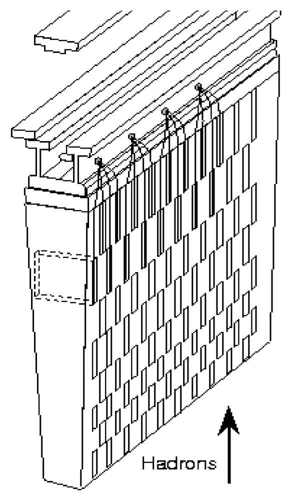
The ATLAS Tile Calorimeter



TileCal is the central hadronic calorimeter of ATLAS. Together with the central LAr EM calorimeter, it will measure the energy and direction of particle jets and contribute to the determination of the event's missing transverse energy, in the region of $|\eta| < 1.7$.

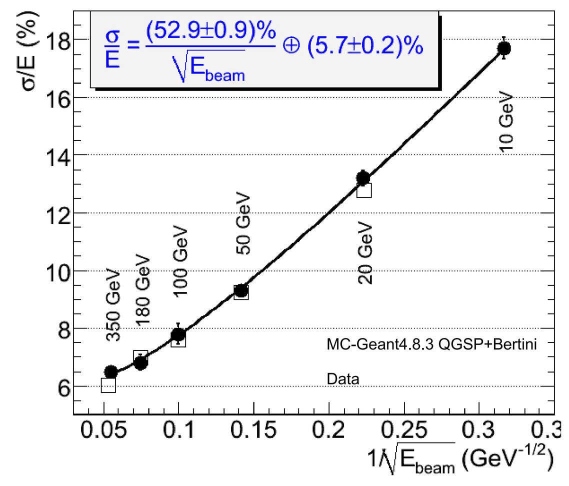
Each of the TileCal barrels (a central, Long Barrel, and two Extended Barrels) are divided along phi in 64 modules ($\Delta\phi \sim 0.1$). The gaps between the barrels are needed for the services of the Inner Detector and LAr calorimeter. The modules are divided in three radial layers, and cells with a $\Delta\eta$ of 0.1 (0.2 for the last layer). Each side of the Long Barrel, and each of the Extended Barrels constitutes one partition, as shown in the lower left figure.

The last EBA module (of 64)



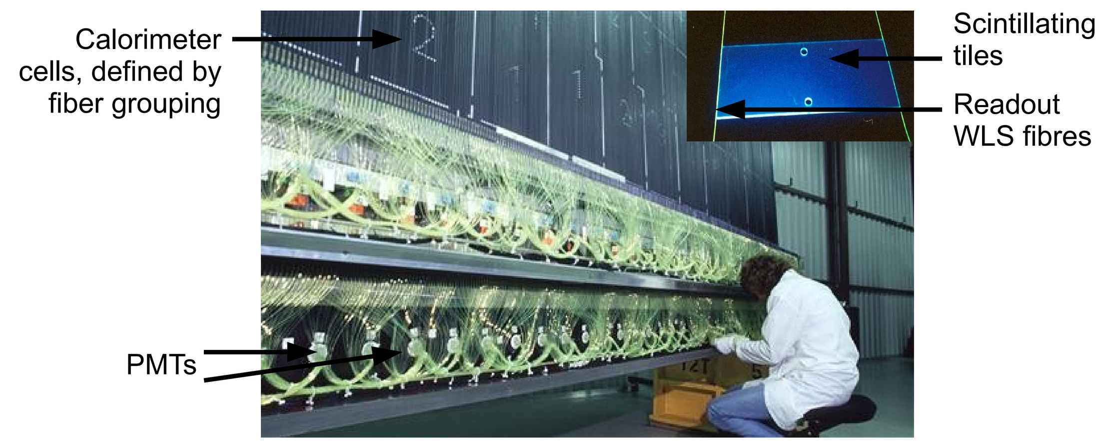
TileCal is a sampling calorimeter using iron as absorber and tiles of scintillating plastic as the active material. The tiles are oriented perpendicularly to the beam direction and staggered in radial depth. The light readout is done by WLS optical fibers, that couple to PMTs in the outer part of each module.

The outer part of each module also contains several detector electronics services: the electronics for signal shaping, digitization and integration, for the analog trigger, the charge injection calibration system, the low voltage power supply and a set of optical fibers dedicated for the Laser calibration system.



TileCal is designed to have very good hermeticity in the central region and very good energy resolution for hadrons.

This distribution shows the resolution for pions, as measured in Test beam, and compared to GEANT4 Monte Carlo. In the full configuration, the constant term is expected to be about 2.5%.



Detector maintenance and status

The TileCal electronics underwent a thorough program of repairs and refurbishing. During the last maintenance period (Nov 08 – May 09), this program was completed, and:

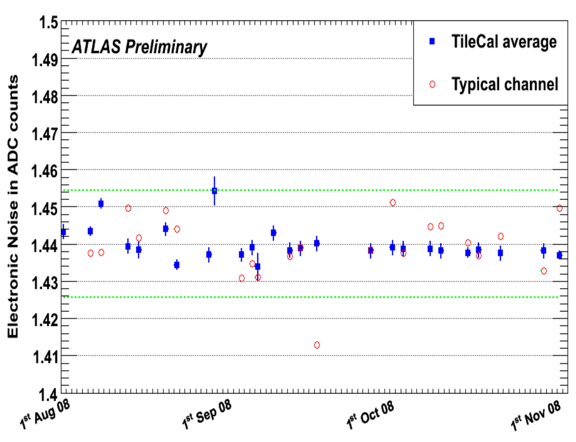
- 81 (32%) front-end electronics drawers were opened and repaired
- 11 (4.2%) low voltage power supplies (LVPS) were replaced and repaired

For future maintenance/repairs, 5% of spares for all components are available.

Status now:
124 channels (1.26%) or 48 (0.93%) cells are masked.
Stability is rather good, and there is continuous monitoring to spot (and repair or mask) any malfunction (e.g. data corruption, high noise, LVPS failures)

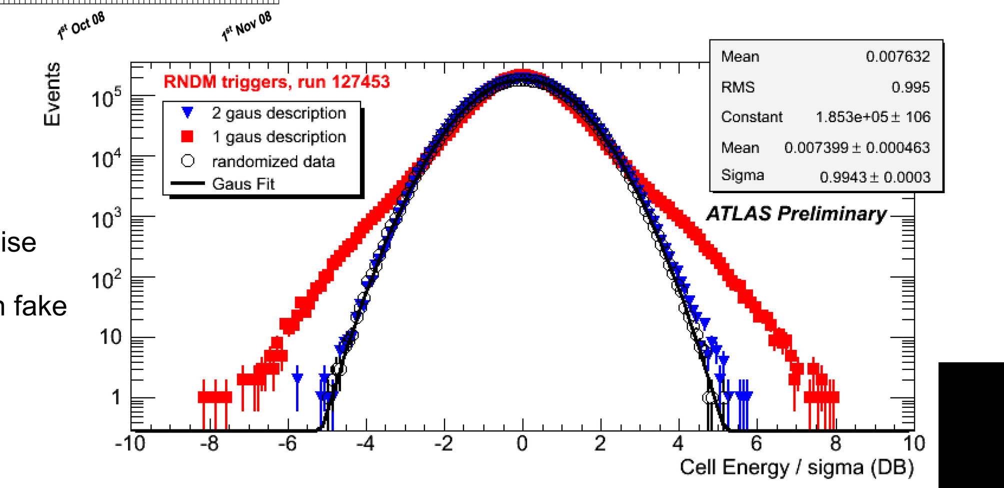
Summary of Component Masking in TileCalorimeter (9-Nov-2009)

Partition	Masked Channels	% Masked	Masked Cells	% Masked
LBA	59	2.05%	23	1.60%
LBC	58	2.01%	25	1.74%
EBA	6	0.29%	0	0.00%
EBC	1	0.05%	0	0.00%
TileCal	124	1.26%	48	0.93%



Noise stability:
RMS/mean of the ADC noise over several months is:
0.3 % for the detector average
1.0% for a typical single channel

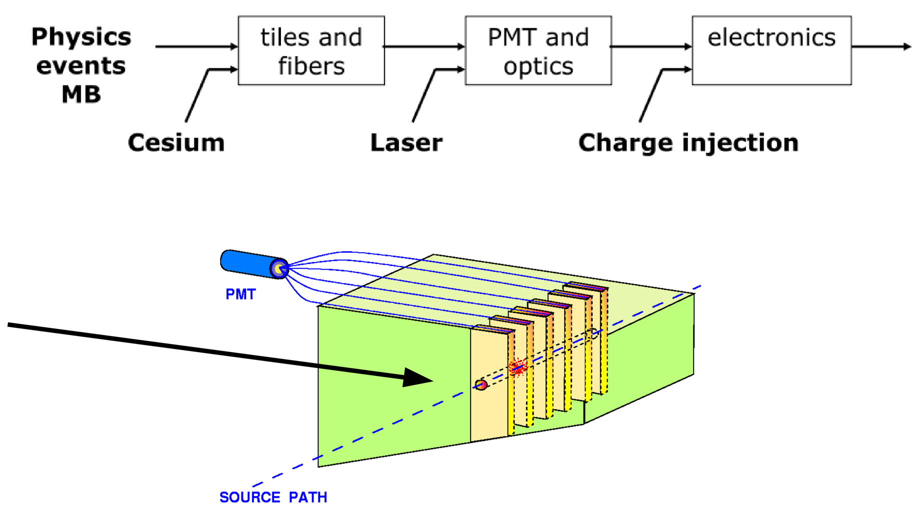
New description of noise with double gaussian, leads to a reduction in fake cell cluster seeds



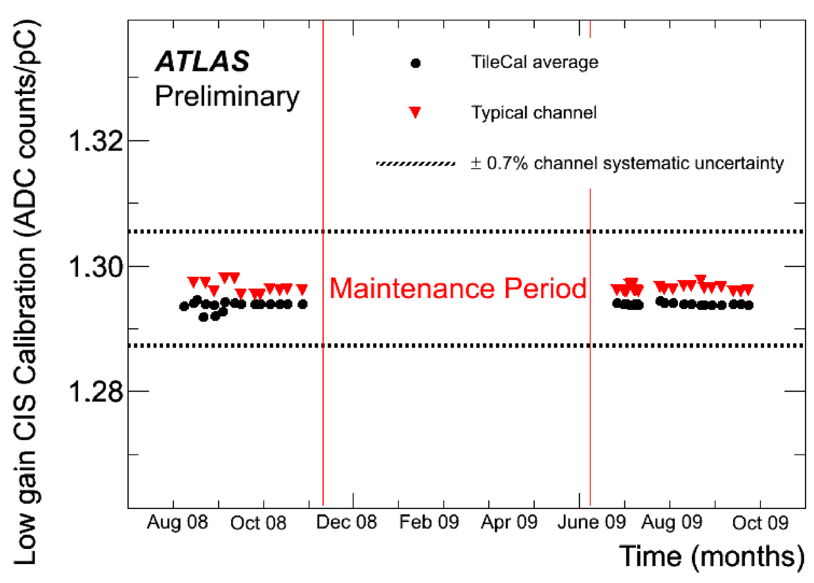
Performance with calibration systems

The response of TileCal is regularly monitored and corrected using a series of calibration systems that focus on each main detector component:

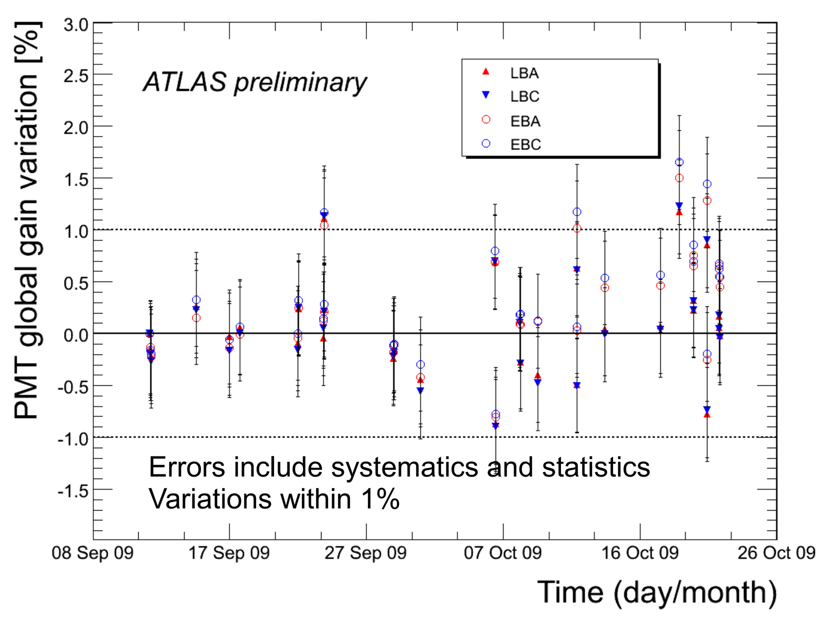
- The Charge Injection System (CIS) generates calibrated amplitude pulses, sent to each electronics channel. It allows the measurement of the number of ADC counts per picoCoulomb.
- The Laser system provides light pulses that are sent to all the PMTs with an optical fiber distribution system. It allows the measurement of the PMT gain stability and the synchronization of the channels.
- The Cesium calibration uses a hydraulic system to move a Cesium-137 source through all the cells of TileCal. The detector response is measured with a charge integration system, and it allows the response of all cells to be equalized, by setting different PMT gains to compensate for non-uniformities in the optics part of the detection chain.



Stability of electronics calibration as measured with CIS

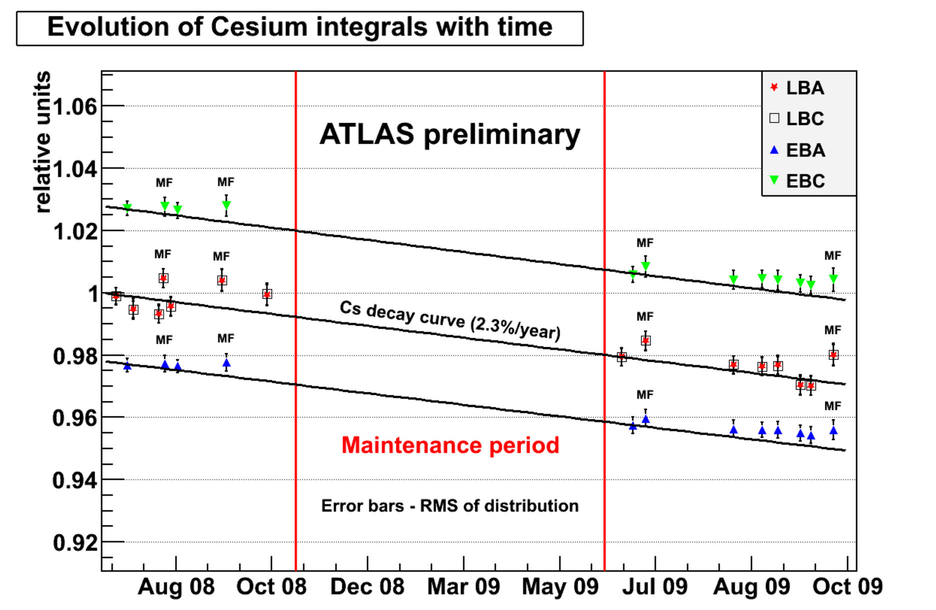


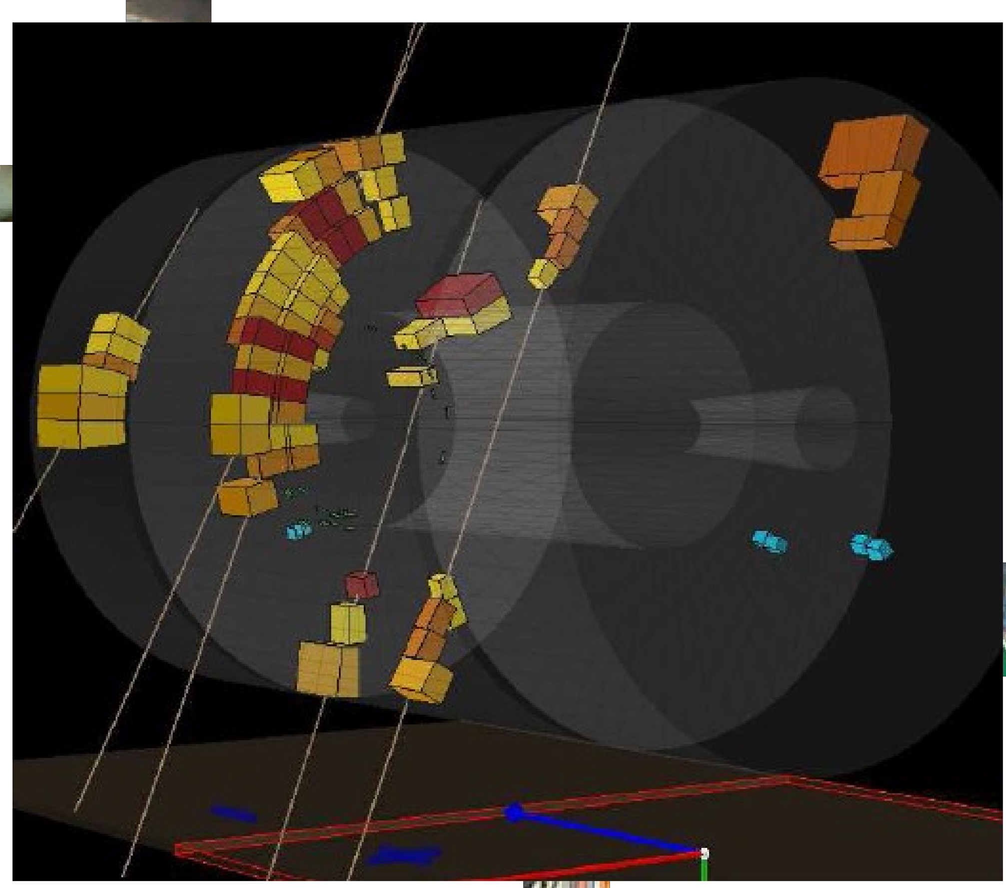
PMT gain stability, as measured with Laser system



Very good stability measured with all systems!

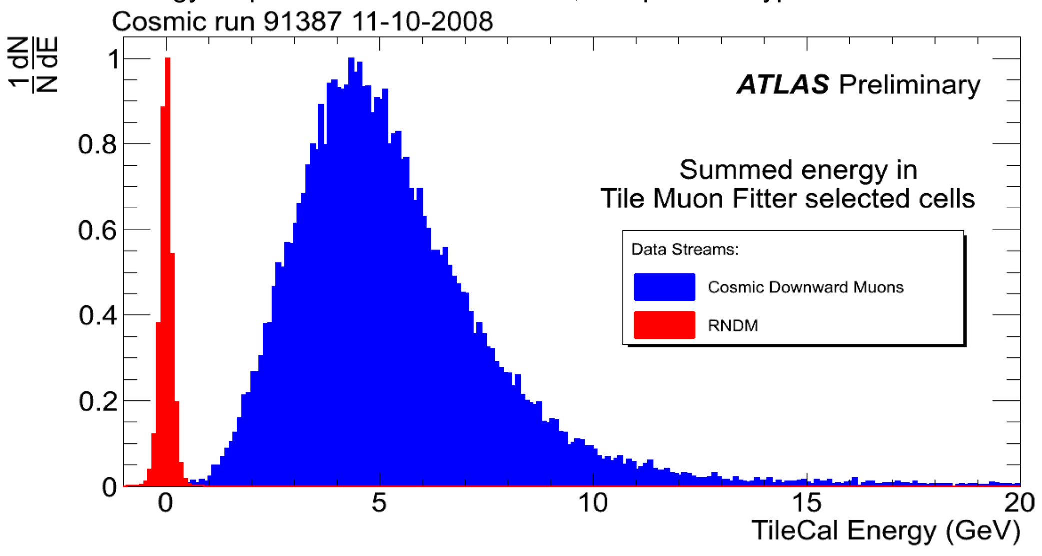
Evolution of Cesium integrals with time





Energy response with cosmics and single beam

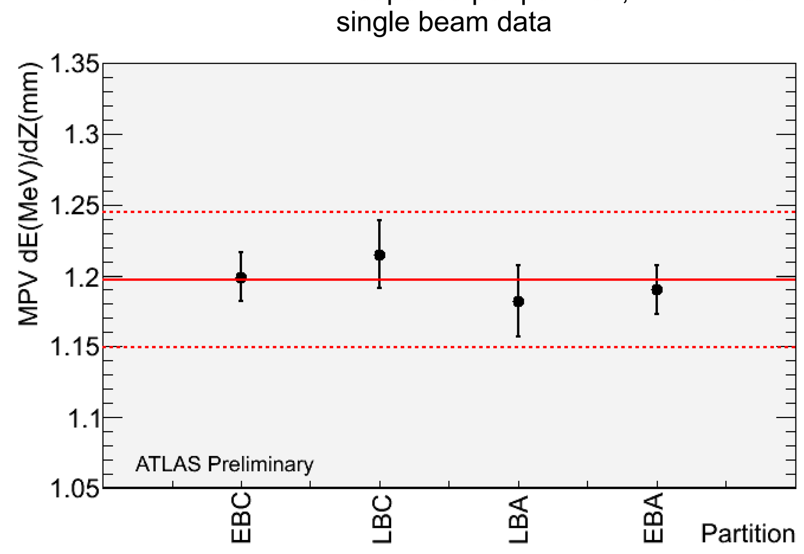
Energy response with cosmic muons, compared to typical noise
Cosmic run 91387 11-10-2008

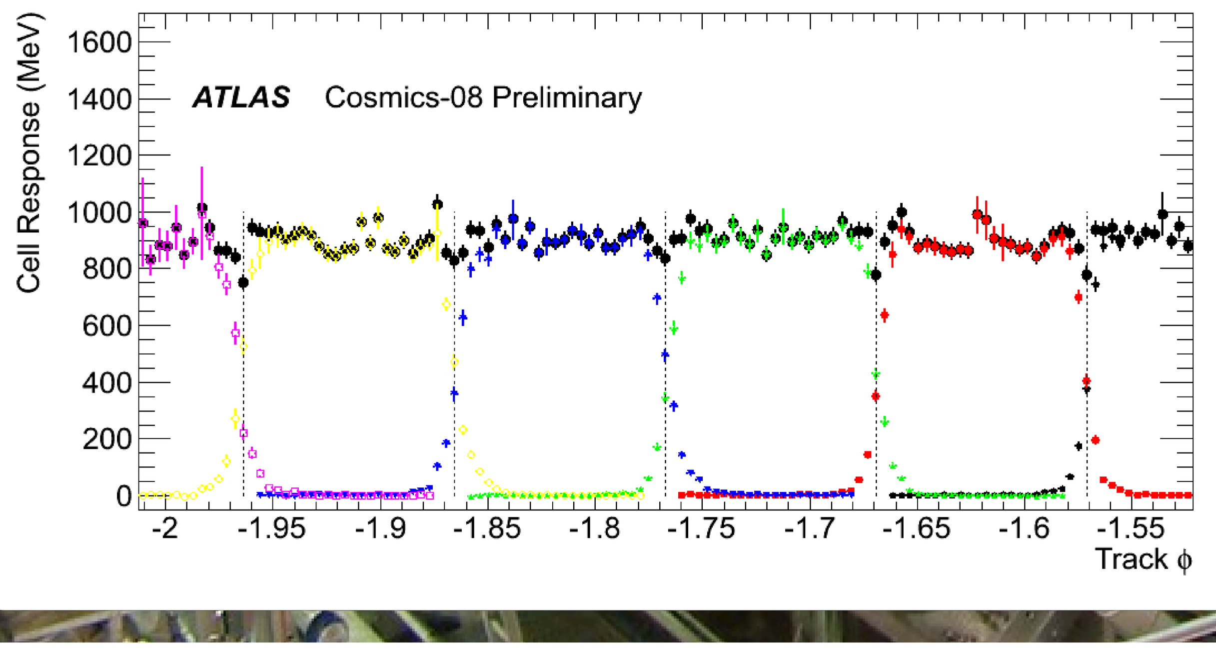


TileCal started taking cosmic muon data in 2005, with only a few modules. The full detector participated in the 2008 combined ATLAS cosmic muon campaign, and the data analysis is currently being finalized.
In addition, the events from the first LHC single beam data have also proved to be quite useful in the performance analysis:

- The signal/noise ratio was measured with cosmics to be about 36, close to the value in test beam (40)
- The response to muons from beam-collimator scraping allowed an estimation of the intercalibration of the 4 cylindrical sections of TileCal to better than 4%, which was the precision of this measurement
- Very good uniformity over phi is observed
- More detailed analysis (uniformity over layers, eta) with cosmics are ongoing, to improve the precision and extend the coverage

Response per partition, with 2008 single beam data



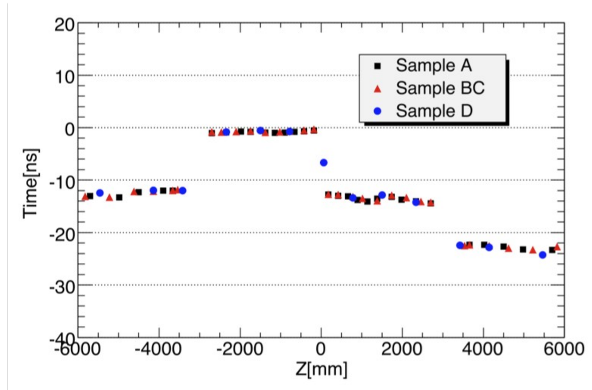


Cell response versus track phi, as measured by the Inner detector, showing reasonable uniformity

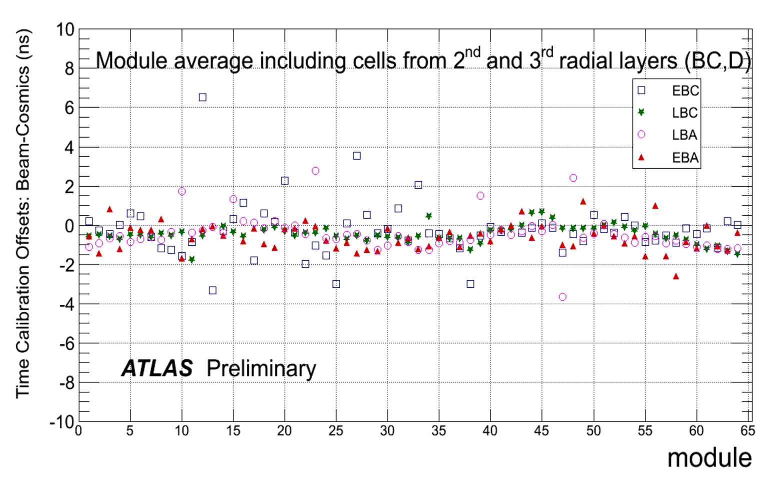
Time response with cosmics and single beam

A good timing response, of about 2 ns, is necessary for the online energy reconstruction, and will also play a role in the rejection of background events not related to the LHC pp collisions, such as cosmic muons, transient noise and beam halo.

The synchronization of the TileCal response is carried out with the laser system, and cross-checked with cosmic muon and single-beam data. This data also allowed some corrections to the laser calibration.

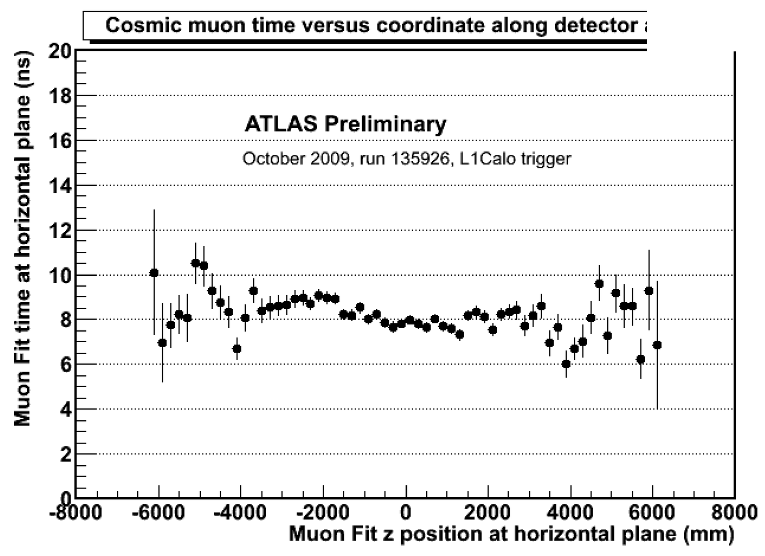


Average time offsets versus cell Z position, as measured with the 2008 single-beam. No inter-partition calibration had been done, hence the ~10 ns offsets



Good consistency between the module averages of offsets measured with single-beam and cosmic data, of about 2 ns.

Cosmic muon time versus coordinate along detector



Time response from a recent cosmics run monitoring distribution, showing good uniformity, after the final calibrations (including inter-partition) were applied.

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